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Study of Combustion of Coal with Magnegas as Additive for Improved Combustion Efficiency: A Review of Present Scenario and Future Scope[1]

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Abstract. Fossil fuels are contributing the largest share in meeting up energy demands of urban lifestyle across the globe. May it be gasoline or coal, all sort of fossil fuels are drilled out of earth crust to burn on the earth surface creating huge burden on air quality. Incomplete combustion of fossil fuels cause pollution of carbon monoxide and other gases. It also eats away the breathable oxygen from atmosphere. Rampant use of coal in power sector causes above problems adding to the global warming phenomenon.
Magnecules and magnehydrogen are seen to be best additives to fossil fuels which can effectively enhance the combustion efficiency of fossil fuels. Present paper discusses the enhancement in combustion efficiency of fossil fuels in terms of increased utility of carbon and improved quality of emission reducing the amount of obnoxious gases.

Keywords: Magnecules, Magnegas, Coal-fired power plants, Co combustion, Hybrid fuels
PACS: 03.65.-w;82.30.Rs; 11.10.Lm;

INTRODUCTION

The new clean combustible gas, magnegas, developed by Prof. R. M. Santilli has precisely a magnecular structure from which it has got its name. Clean water or even domestic sewage water can be converted to magnegas by systematic introduction to electric arc generating a high current in microseconds. The gaseous product, so obtained, is unusual in behavior from the physics and chemistry view points. It is a kind of short range polymeric product wherein two molecules of gas are bonded by a magnetic force of attraction than the conventional covalent bond. Structural details of the properties of this gas is still a subject of discussions and debates. The spectroscopic results and their interpretations are of great interest of the chemists. This is mainly due to the characteristics of this new matter which are beyond the capabilities of interpretation of many spectroscopic and chromatographic instruments available in market. But apart from all these discussions, the most striking feature of Magnegas is that it is proving to be a promising fuel of the 21st century. So far, the success of this fuel is reported as alternative fuel in automobile sector. Some high energy gas fuelled fields like metal cutting tools are also working successfully on this fuel.

Another potential direction of energy studies of magnegas is that the hybrid of this fuel with fossil fuels is expected

[1] One of the author (SSW) is involved in study of ambient air quality. With present knowledge and experience of analysis of SO_2 and NO_x, he can extend his studies for carbon monoxide emissions. He has also carried out study of gases in stack emission for cement manufacturing unit for study of additives in coal.

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to show enhanced combustion efficiency. Magnetized hydrogen from magnegas burns with elevated temperature and helps in complete combustion of carbon in coal and hydrocarbon in gasoline. Thus Hy-Diesel, Hy-Gasoline, Hy-Coal are the new age terms coined by Prof. Santilli [1].

Present paper is aimed to discuss the possibilities of a technology to use magnegas as an additive to coal in order to enhance the combustion efficiency of coal. Another equally important aspect of study is to estimate the environmental benefits of using magnegas and/or magnehydrogen as additive to reduce the emission of green house gases in suppressing the global warming phenomenon in its long term use.

Present Energy Scenario of US and India

Electricity is one of the fundamental forms of energy of modern world. Rapidly depleting reservoirs of coal along with dirty nature of this cheap fuel are a cause of worry for whole world due to increasing pollution and global warming from emitted gases. The way we are burning coal for thermal power, is leaving it incompletely burnt. Thus it is a dual loss in terms of energy as well environmental damage.

Coal-fired power plants are largest emitter of majority of green house gases. Coal-fired power plants presently produce 41 % of global electricity [2]. Coal produces 44 % of the total electricity of United States and also contributes as single largest source of pollution [3]. 68 % of the total electricity of India comes from coal fired power plants [2]. In US, up to 353 coal-fired generators in 31 states (out of a national total of 1,169) are ripe for retirement, equal to a total of 59 Gigawatts of power generating capacity. Collectively they represent as much as 18 percent of the country's coal-generating capacity and approximately six percent of the nation's power [4]. In 2011, approximately 42 percent of United State's electricity was produced by burning coal (EIA 2012a). But today, more than three-quarters of U.S. coal-fired power plants have outlived their 30-year life span, with 17 percent being older than half a century.

Problem with Combustion of Fossil Fuels

Limited and ever depleting sources of fossil fuels along with pollution due to combustion are causing great worry for the future health scenario of all living beings. Extremely serious environmental problems caused by the disproportionate combustion of fossil fuels are well documented by Prof. R. M. Santilli as follows [5]:

1. Combustion of fossil fuels releases in our atmosphere about sixty millions metric tons of carbon dioxide CO_2 per day that are responsible for the first large environmental problem known as "global warning" or "green house effect" [6] which is responsible for disturbed environmental cycles.
2. Combustion of fossil fuels causes the permanent removal from our atmosphere of about 21 millions metric tons of breathable oxygen per day, a second, extremely serious environmental problem known as "oxygen depletion" [7].
3. Combustion of fossil fuels releases in our atmosphere about fifteen million metric tons of carcinogenic and toxic substances per day. The fact is that the U. S. Environmental Protection Agency has formally admitted that diesel exhaust is carcinogenic.

Problem with Combustion of Coal for Power

Combustion of coal is associated with emission of significant quantity of volatile matter and carbon monoxide. This is a loss in terms of energy and also causing pollution due to release of green house gases (CHs and CO).

Six major greenhouse gases are Carbon dioxide (CO_2); Methane (CH_4); Nitrous oxide (N_2O); Hydrofluorocarbons (HFCs); Perfluorocarbons (PFCs); and Sulphur hexafluoride (SF_6) [8]. Out of these six gases, three most common gases in significantly large quantity are emitted from coal fired power plants. In burning fossil fuel like coal, about 60 % of energy in the original fuel is literally thrown through the fluke, and so is the related cost, due to the notoriously poor combustion [5]. Thus, majority of the combustible and energetic content is lost unutilized in the process. Burning coal demands billions of gallons of cooling water from ever depleting rivers and lakes, and leaves behind vast quantities of toxic ash residuals, while coal mining causes extensive and lasting damage both to human

health and the natural environment (Gentner 2010; NRC 2010) [4]. Thermal power plants release carbon monoxide to a certain extent indicating incomplete combustion. Conversion of CO to CO_2 in atmosphere causes thermal pollution due to exothermic nature of this conversion. 18 to 20 ton of coal is burnt for generation of 1 MW energy. Thus a 2000 MW power plant burns about 40000 ton of coal per day and release a huge volume of CO and other Harmful gases in atmosphere. According to the World Bank estimate emission reduction would have a minimal impact on GDP which would be offset by savings through improving health while substantially reducing carbon emission.

A 10 % particulate emission reduction will lower GDP only modestly. GDP will be about $ 46 billion lower in 2030 due to interventions, representing a loss of 0.3 % compared to business as usual.

A 30 % particulate emission reduction on the other hand will lower GDP by about $ 97 billion, or 0.7 %. It points to the need of improving air quality by minimizing the emission of gases and particulate matter which will help improving air quality and health scenario. But it does not seem to be accepted worldwide due to shortage of electricity.

The coal reservoirs invite coal fired power plants to specific coal rich regions and no other alternate fuel can meet up this requirement in any other part of the country. Therefore we cannot altogether rule out the use of coal for power. It is the need of time to come up with a realistic solution to clean the combustion of coal in power and other small coal using sectors like brick making to cement and metallurgical industries.

Thus it is more positive approach to think of a cleaner additive to coal than going for alternate fuel. Additive which is not restricted to any geographical area will be more helpful for economy and cleaner process of coal fired power plants.

Only viable option is to add a suitable additive for cleaner co-combustion process. Pure hydrogen gas can meet up the thermodynamic requirements. Injection of hydrogen as an additive in the flame of fossil fuels burns the uncombusted component of the exhausts in a way proportional to the used percentage of hydrogen. But, use of hydrogen as an additive has several limitations and restrictions. Limitations are mainly due to cost and difficulty in handling.

Therefore, magnegas can prove to be a better additive for co-combustion with coal.

Magnegas- The Best Option for Hydrogen as an Additive at Present

Looking at the energy requirement of world and our dependency on coal for power, it seems to have no direct alternative any next morning. Conversion of carbon monoxide to dioxide in the atmosphere is causing thermal pollution. Volatile matter escaping away also causes potential energy loss. Hence the priority need is clean and complete combustion of the existing fossil fuel and utilizing the maximum available carbon of the fuel. This can be done by injecting MagneGas (MG) [5, 9, 10, 11, 12, 13] along with the conventional fossil fuel. The property of magnecules [5] to undergo magnecular combustion [5, 9, 10] with high energy output is due to weak magnecular bond. This is exploited for the industrial development of new clean fuels such as magnegas. MagneGas is a good additive for the cleaning of fossil fuel exhaust because:

1. When produced from the recycling of water-based liquid wastes, magnegas contains about 65% hydrogen, thus qualifying as an effective additive to improve fossil fuel combustion;

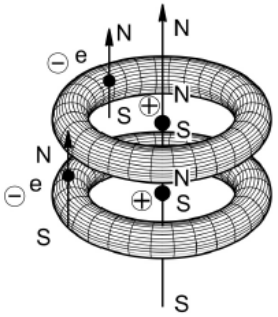

FIGURE 1. A new chemical species (Experimentally Confirmed recently) called MAGNECULE whose bond is NOT that of valence. source: New Science for a New Era [9]

TABLE 1. Comparison of flue gases and stack temp in combustion of coal and coal+magnegas, Courtesy: www.magengas.com/reports/cocombustion.[11]

Electricity Generation	Coal	Coal and MagneGas
Oxygen	11%	13%
Carbon Dioxide (CO_2)	15%	9% (40%)
Carbon monoxide (CO)	58 ppm	28 ppm (52%)
Nitrous oxide (NO_x)	160 ppm	46 ppm (71%)
Stack temp	371 ^{0}C	3000 ^{0}C

2. The remaining components of magnegas are rich in oxygen, thus helping to alleviate the large oxygen depletion caused by fossil fuel combustion.

Also, the cost of magnegas is competitive over that of fossil fuel, particularly when produced by the electric power plants, because of the reduced cost of electricity and the possibility of producing magnegas from the recycling of city sewage, with a consequential income that covers most of the operating costs of PlasmaArcFlow Recyclers.

Magnegas can be synthesized on site by using any source of water and applying the famous technique pioneered by Prof. R. M. Santilli. The magnegas can be used along with coal as additive for effective co-combustion. Flame temperature of magnegas is upto 10500 F which helps in combustion of all the carbon and traces of nitrogen and sulphur to their final oxidation products in the combustion chamber itself. This ensures complete combustion of carbon to generate maximum energy. It also helps to burn all the volatile matter formed due to internal reaction of carbon and hydrogen from coal. Localized combustion of all combustible elements from coal is the main objective which can be best fulfilled by using magnegas as an additive for co-combustion with coal. Some experiments are already conducted by Magnegas Corp. in collaboration with various partners across Europe, U.S. and Australia and they have reported a positive outcome of the experimental trials [14].

Further, it is also observed in earlier studies that co-combustion of magengas has reduced the carbon dioxide emission by about 30 to 40 % and reduced emission of carbon monoxide [14]

Below mentioned is a tabulated interpretation of the results of combustion of coal in comparison with co-combustion of magnegas and coal.

As magnehydrogen would be more energetic than magnegas due to resemblance of MH with hydrogen, magnehydrogen can be used in place of magnegas as a refinement to the co-combustion experiment. The first independent experimental verification of the new species of Santilli MagneHydrogen was reported in October 11, 2011, by D. Day [12] of the Eprida Laboratory, 3020 Canton Road Suite 104, Marietta, GA, via the use of a VSA station for the separation of MH from MG, the use of a GC-TCD for the measurement of the percentage of hydrogen in the separated gas, and the use of conventional methods for the measurement of molecular weight. In this way, Day reported a species of MH with about 97.5 % pure Hydrogen and having 3.89 times the specific weight of H_2 and a consequential energy content of 1167 BTU/scf.

As reported by Yang [10] from an industrial viewpoint, it is sufficient to achieve a species of MH with at least 3.3 times the specific weight of H_2 to have the same energy content of 1000 BTU/scf of Natural Gas (NG). In fact, under said conditions, MH would avoid the current needs to liquefy Hydrogen in order to achieve a sufficient range, since MH can be compressed like NG. Additionally, the magnecular structure of MH avoids the traditional seepage of Hydrogen through the walls [16, 5], thus allowing long term storage that is currently prohibited by molecular Hydrogen due to current environmental laws.

Magnehydrogen is a cluster species and about 7.4 times heavier than hydrogen. This anomolous weight compared to conventional gaseous molecules helps in reducing the leakage of these novel species from pipeline. Permeability issues needs to be answered while passing hydrogen through pipeline but magnehydrogen has an advantage due to its polymeric nature. Moreover, energetically it is equivalent to hydrogen and generates a high flame temperature which can prove key to cleaner combustion of coal.

Thus magnehydrogen is the closest choice to replace hydrogen as an additive and in some physical properties discussed above, it is even better to hydrogen.

Indian coal is known for its high ash content. Coal-fired power plants generate a huge quantity of fly-ash. As per the estimates of Magnegas Corporation based on studies conducted at their place, there is an elimination of particulate matter when using magnegas with coal as additive. This estimate is a ray of hope for cleaning the combustion of coal-

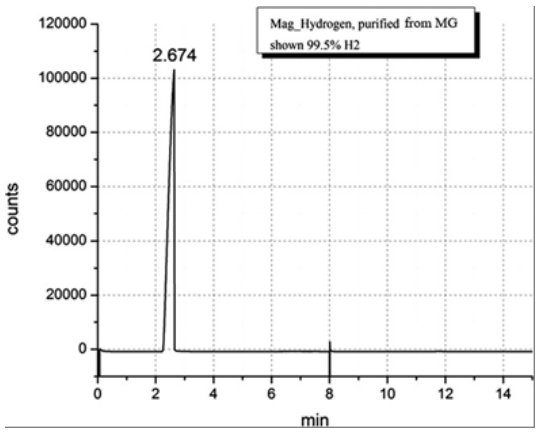

FIGURE 2. A GC-TCD scan of MagneHydrogen showing no appreciable difference of MH with pure hydrogen.[12]

fired power plants in many states of India. Central Indian coal mines deliver coal with ash as high as 38 to 40% and fly ash emitting from the coal-fired power plants is a cause of land, soil and air pollution in the area. Apart from larger coal based power plants, there are many captive to micro power plants operated on co-operative basis in villages. These power plants meet up the energy requirement of those villages. Due to lack of any sophisticated emission controlling technologies, these power plants emit a high amount of poisonous gases like CO_2, CO and NOx. Due to low stack height of these steam engine based power units, the workers are exposed to poor health and environmental conditions. The clean up aimed with co-combustion of coal with magengas can provide better environmental conditions to workers in small coal fired units.

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